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ABSTRACT

Population growth and resource depletion are discussed. The need is stressed for policy makers to understand how population projections relate to the carrying capacity of the earth's basic biological systems. Because the earth's resources are limited, it is essential that policy makers in developed and developing nations be able to analyze the relationship between population and resources such as fisheries, forests, croplands, and grasslands. Economic and social stresses have already resulted in over-fishing, over-grazing, shrinking forests, urban slums, unemployment and, since 1974, annual double digit inflation. One major constraint to unlimited population growth is the oil supply. Petroleum is the principal fuel that powers the global economy. The changing petroleum supply necessitates not only vigorous conservation programs but also establishment of policy priorities which will assure adequate oil supplies for essential purposes such as food production. Population policies which have been devised to deal with population growth include family planning assistance and controls on rural-urban migration. The conclusion is that policy makers must devise ways of stabilizing population at a level far lower than currently projected in order to avoid deterioration of the earth's biological resource base and of the living standards of more and more people. (DB)

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Resource Trends and Population Policy: A Time for Reassessment

Lester R. Brown

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Introduction

As of early 1979, there are some 4.2 billion people in the world. Our numbers are increasing by some 70 million per year or 192,000 per day. Although the rate of world population growth has begun to slow, the reported year-to-year additions continue to increase. On a finite globe, population growth cannot continue indefinitely. Everyone agrees that population growth will eventually halt. What is not agreed upon is the level at which this will occur.

The official U.N. medium-level population projections, which are widely used for planning purposes throughout the world, show population expanding to some 12 billion before eventually stabilizing a century or more hence.[1] These population projections are the product of two sets of assumptions—one explicit and one implicit. The explicit assumptions are demographic in nature. They include country-by-country assumptions about future fertility levels, sex ratios, life expectancies, and numerous other demographic variables. If these explicit assumptions hold, then the projected increases in world population will materialize.

But population growth does not occur in a vacuum. Current projections of world population are based on the implicit assumption that the basic energy, food, and other natural resources required to support human life are going to be as available in the future as they have been in the past. They assume that the production of the major biological systems—fisheries, forests, grasslands, and croplands—that satisfy basic human needs for food, shelter, and clothing will continue to expand along with population.

I am indebted to my colleague Christopher Flavin for his assistance with the research and analysis underlying this paper.

6 Human population growth is also closely tied to the earth's energy resources. The great postwar growth in food production that sustained the massive increase in world population depended heavily on the abundance of cheap energy, particularly oil. Recent changes in oil production and pricing policies in key producing countries are altering the oil supply situation. As the oil outlook changes, population projections must be reconsidered.

Assessing the impact of population on the earth's resources is complicated analytically because population growth and rising affluence both increase pressure on the earth's resources. Not only are the effects similar, but from 1950 through 1973 each accounted for roughly half of the 4 percent annual growth in the world demand for goods and services. Since then, however, global economic growth has fallen to only 3 percent per year, and the population component of the overall growth in global demand has become dominant.[2]

An abundance of evidence indicates that pressures are mounting in a way that will influence future population trends. To be realistic, demographic models need to incorporate feedback mechanisms that reflect changing attitudes toward population size at both the national and the individual levels as the various ecological and economic stresses associated with continued population growth become evident. This in turn calls for an analysis of the relationship between population growth and both the earth's basic biological resources and its oil supplies.

Pressures on Biological Resources

An understanding of the carrying capacity of the earth's basic biological systems is a prerequisite of meaningful population projections. A biological concept, carrying capacity is a management tool widely employed by ranchers, wildlife managers, and others concerned with the sustainable yield of local biological systems. The failure to incorporate this concept into considerations of future popu-

"As world population has moved toward four billion and beyond, human needs have begun to outstrip the productive capacity of many local biological systems."

lation size has led to the projection of vast increases in numbers, even though in many local situations populations are already outgrowing the biological systems they depend on. 7

The increase in human numbers thus far has depended heavily on the product of the earth's basic biological systems—fisheries, forests, grasslands, and croplands. These four systems supply not only all our food but, with the important exception of minerals and petrochemicals, all the raw materials for industry as well. With the exception of croplands, these are essentially natural systems that cannot always be improved by human management.

The carrying capacity of the three natural systems is essentially fixed by nature. A natural grassland can support a set number of cattle or a somewhat larger number of sheep. A fishery can supply the protein for a certain number of people and the forest surrounding a village can satisfy the firewood needs of a given population. If the trees removed from a forest exceed its rate of regrowth, then the forest will eventually disappear. If the catch from a fishery exceeds its regenerative capacity, stocks will dwindle, and it will eventually collapse. If herds grow too large, livestock will decimate grazing lands and the resulting erosion will turn the pastures into barren wastelands.

Once the growth in human demand reaches the sustainable yield threshold of a given biological system, further increases in demand often can be satisfied only by consuming the productive resource base itself. This in turn causes it to shrink faster. Once the sustainable yield threshold is crossed, further population growth has a double-edged effect, simultaneously expanding demand and reducing the supply.

As world population has moved toward four billion and beyond, human needs have begun to outstrip the productive capacity of many local biological systems as currently managed. At the global level, these excessive pressures can be seen most clearly for oceanic fisheries. Throughout most of human existence, there were more fish in the oceans than humans could ever hope to catch or consume. As

8 world population expanded following World War II, so did the fish catch and the investment in fishing fleets. The catch increased along with world population until the latter reached 3.6 billion in 1970. At this point, population continued to grow but the fish catch did not. Since 1970, investment in fishing fleets and fish farming has increased markedly, but the annual catch has remained around 70 million metric tons. With the catch leveling off since 1970, the fish supply per person has fallen by 13 percent. (See Table 1.)

The second global life-support system that is under mounting pressure is grasslands. Although data are not as complete as for fisheries, the signs of excessive stress are unmistakable. The pressures are evident in the deteriorating condition of grasslands in vast areas of the world and in the production trends of livestock products themselves.

From early biblical times until quite recently, the number of cattle, sheep, and goats has expanded more or less apace with the human population, supplying meat, milk, butter, cheese, leather, and wool. Although the dairy industry in the industrial countries relies heavily on the use of grains and other feed concentrates, most of the world's beef and mutton are produced with forage, largely grasses of one type or another.

The areas of the world used for grazing are almost without exception those areas that are too dry or too steeply sloping to sustain crop cultivation. Once the plow has run its course, the area remaining in grasslands around the world, roughly double that in crops, is essentially fixed by nature. Human intervention can sometimes raise the productivity of grasslands, and productivity can always be reduced through mismanagement, but the resource base itself cannot be significantly expanded. Indeed, as world population has expanded since mid-century, the area of grassland per person has diminished steadily.

The trends in world mutton and wool production are remarkably similar to those in the fish catch. (See Table 1.) While the per capita fish catch peaked in 1970, the per capita production of mutton

Table 1: World Production Per Capita of Key Commodities of Biological Origin, 1960-78, With Peak Year Underlined

	Forests	Fisheries	Grasslands			Croplands
Year	Wood	Fish	Beef	Mutton	Wool	Cereals
	(cubic meters)		(kilograms)			
1960	—	13.4	9.43	1.91	0.86	287
1961	0.65	14.3	9.67	1.91	0.85	278
1962	0.66	14.5	9.90	1.90	0.85	292
1963	0.66	14.7	10.25	1.89	0.83	286
1964	0.67	16.1	10.12	1.84	0.81	297
1965	0.67	16.2	10.09	1.82	0.79	288
1966	0.67	17.1	10.39	1.80	0.80	308
1967	0.67	17.7	10.59	1.92	0.79	308
1968	0.66	18.4	10.86	1.92	0.80	318
1969	0.66	17.7	10.90	1.88	0.79	316
1970	0.66	19.5	10.80	1.90	0.76	314
1971	0.66	19.2	10.57	1.91	0.74	335
1972	0.65	17.6	10.75	1.92	0.73	319
1973	0.66	17.5	10.63	1.83	0.67	337
1974	0.65	18.1	11.16	1.80	0.65	322
1975	0.62	17.6	11.49	1.80	0.67	321
1976	0.62	18.2	11.81	1.79	0.65	342
1977	0.62	17.4	11.53	1.78	0.63	333
1978*	0.61	16.6	11.21	1.77	0.64	340

*Preliminary estimates.
Source: Food and Agriculture Organization and U.S. Department of Agriculture.

peaked in 1972 at 1.92 kilograms per person. The worldwide decline of some 7 percent since then reflects both short supplies in many developing countries and a strong consumer preference for beef in some industrial countries. Wool production per capita peaked at 0.87

kilograms or roughly two pounds in 1959. The 28 percent fall in per capita production since then is due to a combination of production constraints and strong competition from synthetic fibers.

World production of beef has nearly doubled over the last two decades, leading to substantial gains in per capita consumption. But if world population continues to expand, a point will eventually be reached where it will no longer be possible for beef production to keep pace. Strongly influenced by the multi-year North American cattle cycle, beef production per capita has fluctuated throughout the postwar period, but it has invariably done so around an upward trend. Since 1976, however, it has been declining. Projections for 1979 indicate a fall in world beef production per person of 9 percent since 1976.[3]

World beef production can undoubtedly expand further, but overgrazing and the growing demand for cereals for direct human consumption raise doubts as to whether per capita beef production will ever resume the strong upward trend of the previous two decades. Like mutton, per capita beef production may now have begun a long-term decline.

The world's forests are also under mounting pressure. While the demand for forest products is spiraling, the area in forests is shrinking by some 11 million hectares, an area the size of Cuba, each year. Deforestation as a result of excessive demand for wood is not an entirely new problem. What is new is the global scale. By the time world population passed the three billion mark in 1961, national populations were outstripping the sustainable yield of forests in most Third World countries.[4] Worldwide, wood production per capita peaked in the mid-sixties at 0.67 cubic meters. Since then it has fallen by an estimated 9 percent. (See Table 1.)

The relationship between population growth and forest resources is a complex one. The demand for lumber, still the universal building material, is determined by the size of world population, its level of affluence, and its annual increase. Each year some of the world's

housing must be replaced as it ages and deteriorates. And each year 70 million additional people need housing. The combined need for replacement and new housing levies an ever-growing claim on the world's forests.

The demand for firewood, the principal fuel in the countries with the fastest-growing populations, is rapidly outstripping the sustainable yield of local forests. In *Losing Ground*, Erik Eckholm points out that as the forests recede, villagers are often forced to use dried cow dung for fuel. This in turn deprives soils of nutrients and humus, leading to a decline in soil fertility. As the process continues, the downward spiral acquires a momentum of its own, closing the poverty circle ever more tightly. This syndrome, now commonplace in the Third World, illustrates how excessive pressures on one biological system can affect another.[3]

While the use of firewood has declined historically as development has proceeded, the use of forest products for newsprint, packaging, and other purposes soars with modernization. In the early stages of economic development, for example, rising literacy levels combine with rapid population growth to generate an inordinately rapid growth in the demand for paper. The net result is a continuing strong demand for wood products as economic development progresses.

Trends in the forested area in individual countries vary greatly. In most of the advanced industrial countries in Europe and North America, and in Japan, the area in forests has stabilized. In the case of Western Europe and Japan, this has been possible because of the substantial imports from tropical countries and from North America. As the forests continue to shrink in the Third World, the inevitable exhaustion of supplies or the imposition of export restrictions will confront the importing countries with a difficult set of adjustments.

In terms of human well-being and survival, the single most important product from a biological system is cereals—the grain crops that occupy some 70 percent of the world's cropland area. Together, wheat, rice, corn, and other cereals supply well over half our food energy

supply when consumed directly and a sizable part of the remainder when consumed indirectly in the form of livestock products and alcoholic beverages. Between 1950 and 1971, world cereal production nearly doubled and production per capita climbed from 251 kilograms to 335 kilograms, an increase of over 30 percent. Since 1971, however, cereal production per person has leveled off. (See Table 1.)

This leveling off can be traced to a lack of new land to bring under the plow, rising energy prices, rigid agrarian structures, the conversion of cropland to nonfarm uses, soil erosion, and other forms of soil degradation. Expanding the area under irrigation is becoming much more difficult. Diminishing returns on the use of additional fertilizer in the agriculturally advanced countries is also slowing the growth in food production.[6]

The pressures on croplands are mounting as population growth simultaneously expands the demand for cropland while accelerating the conversion of cropland to nonfarm uses. Although the total cropland area expanded somewhat between 1950 and 1975, the area per person shrank by an estimated 24 percent. During the final quarter of this century it could fall by another 30 percent if projected increases in population materialize.[7]

Over time, it is becoming more difficult to offset the shrinkage in cropland area with rises in land productivity. Compounding the shrinkage in cropland per capita is the growing erosion and degradation of soil as a result of demand pressures and mismanagement. According to a U.N. survey, fully one-fifth of the world's cropland is losing topsoil or being otherwise degraded at a rate that will undermine productivity over the long run.[8] In some countries, this topsoil loss is being masked in the short run by the heavy use of chemical fertilizer.

Even more discouraging than the leveling off in cereal output per person is the possibility that the same pressures will lead to a gradual decline in the years ahead. All of the principal forces that have led to the stagnation of per capita grain output during the seventies will be

"The per capita production of fish, forest products, and mutton peaked when world population was between three and four billion."

at least as strong, if not stronger, during the eighties and nineties. Short of an abrupt slowdown in world population growth, the prospect of a decline in per capita food production between now and the end of the century must at least be considered. A more equitable distribution of food supplies could ameliorate the impact of this decline, but the rationing of scarce supplies through rising prices in the world market may leave some people unable to get enough food while others enjoy a surfeit. 13

Projecting the yield of biological systems to the end of the century, particularly when the productive resource base is shrinking, is not an easy task. Although no one can project with precision the trends in per capita production of basic biological resources, recent historical evidence does provide some clues at least about the direction of the trends, if not their magnitude. The record shows that world production of wool per capita peaked and began to decline just before world population reached three billion. The per capita production of fish, forest products, and mutton peaked when world population was between three and four billion. Beef production per person may have peaked right at the four billion point. Per capita cereal production may be reaching its maximum level at just over four billion people before it also begins a gradual decline.

A projection of the world fish catch illustrates the difficulties ahead if population growth continues as projected. The yield of oceanic fisheries is influenced by both the basic biological potential of the fisheries and the human capacity to manage them to their full potential. Calculating the biological yield potential requires rather precise information on each individual species, including their age-group distribution, reproduction and maturation rates, and relationship to other species in the oceanic food chain. Effectively managing fisheries so as to avoid overfishing requires a high level of political maturity and a willingness to sacrifice a larger catch in the short term for a smaller sustained yield over the long run.

One way of projecting the world fish catch to the end of the century is simply to extrapolate the trends of the past eight years, during

which the catch has fluctuated around 70 million tons. A forthcoming study by the U.S. Government indicates that this may be the best that can be hoped for.[9] Under this assumption, the fish catch per person would fall by some 42 percent between 1970 and 2000.

Another way of projecting the future catch is to assume that management of fisheries will improve; that the few remaining underexploited stocks, such as the tropical fisheries around the Indonesian islands and those in the Indian Ocean, will be fully developed; and that fish farming will expand substantially. Given this combination of assumptions, a projected increase in catch to 85 million tons by the end of the century is within the realm of possibility. Such an increase would lead to a decline in the catch per person from 19.5 kilograms in 1970 to 13.6 kilograms in 2000—a drop of 31 percent. (See Figure 1.) Almost any reasonable set of assumptions regarding the fish catch between now and the end of the century leads to a continuation in the decline in the per capita fish supply of the past eight years. If projected gains in population growth materialize, the only real questions may be how much the per capita catch declines, how the decline affects seafood prices, and who is hurt most by the decline.

Aside from reducing demand, there are two principal responses to the scarcities of basic biological resources—trying to improve the productivity of the system and substituting synthetic products. In an effort to cope with the scarcity of fuelwood and lumber, some countries are turning to tree farming, the systematic cultivation of specially adapted, fast-growing species. Farmers in the United Kingdom and New Zealand fertilize grasslands heavily in an attempt to raise the livestock carrying capacity of their holdings. Unfortunately the share of the world's grasslands where there is enough rainfall to make this feasible is very small. While these human interventions to improve the productivity of natural systems are important, particularly at the local level, they have not been sufficient to reverse the unfavorable trends of recent years. The prospect for expanding these energy-intensive interventions will be influenced by future oil price and supply trends.

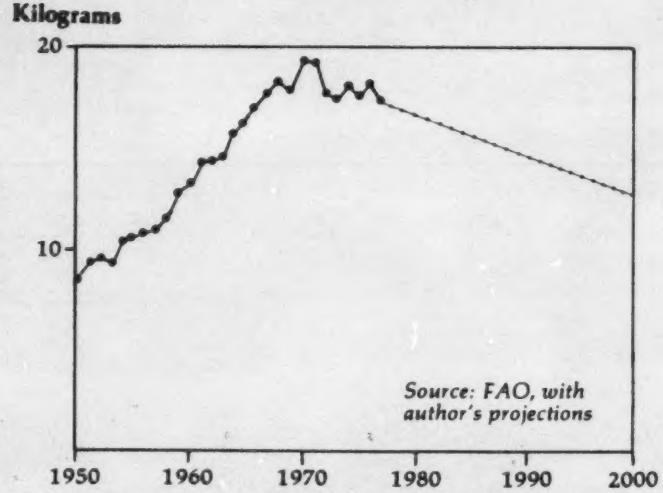

Figure 1: World Fish Catch Per Capita 1950-77, With Projections to 2000

The scarcity of commodities of biological origin and of cropland has been partially offset by the extensive substitution of petroleum and petroleum products. Kerosene has been substituted for firewood and charcoal. Gasoline and diesel fuels used to power tractors and irrigation pumps have been substituted extensively for draft animals and for human muscle power. In their efforts to meet the continuously expanding demand for food, farmers have substituted fertilizer for the new land that is no longer available. Between 1950 and 1978, the world's farmers increased their use of energy-intensive chemical fertilizers more than sixfold, from 15 million tons to over 90 million tons. The use of pesticides, many of them produced from petrochemicals, has climbed even more rapidly.[10]

16 The substitution of synthetic materials, produced by the petrochemical industry, for commodities of biological origin has also become widespread over the past four decades. Per capita production of wool, cotton, and other natural fibers leveled off or declined, and the use of synthetic fibers has climbed, partly because of relative prices and partly because of consumer preferences. In 1950, synthetic fibers accounted for only 1 percent of the world fiber supply. But by 1978 their share had climbed to an estimated 35 percent—compared with 47 percent for cotton, 6 percent for wool, and 12 percent for rayon, a fiber produced largely from wood pulp. In summary, fully one-third of the clothing and textile demands of four billion consumers are now met by products of synthetic origin.[11]

With rubber, the substitution has progressed even further. Although world production of natural rubber has managed to keep pace with population growth since 1950, it has fallen far behind the rapid overall growth in demand for rubber, a demand spurred by rising affluence. By 1978, synthetic rubber produced by the petrochemical industry accounted for over two-thirds of the world's rubber supply.[12]

Plastics, another synthetic product dependent on petroleum, have been widely substituted for such commodities of biological origin as paper, cardboard, wood, and leather. The use of plastics in packaging in the United States alone totaled 3.6 million tons in 1978, or some 16 kilograms per capita. Plastics are now substituted extensively for wood in the building, furniture, home appliance, and houseware industries. As the leather supply falls behind demand, the world's footwear and leather-goods industries are turning increasingly to synthetic products.[13]

This use of oil and of products derived from it has figured prominently in the economic evolution of the third quarter of this century. The substitution has eased the pressures on many biological systems, but whether it can continue depends on future petroleum supplies and prices. If this process is reversed, either because of changing price relationships or because of absolute shortages as petroleum supplies dwindle, it will intensify pressure on the earth's basic bi-

ological systems. In the absence of some revolutionary new technologies and energy sources, future population growth may thus be strongly influenced by the future supply and price of oil.

The Petroleum Constraint

Between 1950 and 1973 the world economy expanded at some 4 percent per year. This unprecedented increase in the output of goods and services was closely tied to the 7 percent annual growth in world oil output during the period. Without such a rapidly expanding supply of cheap oil, it is difficult to imagine either the impressive economic growth or the enormous increase in world population.

The ways in which oil has boosted the earth's population sustaining capacity are numerous. Not only is oil the principal fuel that powers the global economy, but it has numerous special uses for which there are no readily available substitutes. Any projections of future population growth must therefore take into account the changing petroleum supply.

The world of the foreseeable future promises to be one where petroleum or its equivalent is scarce and costly and where the supply is growing slowly, if at all. Such a situation will contrast sharply with the time when oil was cheap and when the supply was growing several percent per year. National population policies and individual childbearing decisions will be affected both directly and indirectly by the changing energy situation.

The period since 1950 divides into two distinct eras in the population/petroleum relationship. From 1950 to 1973, world oil production increased more than fivefold, rising from 3.8 billion barrels in 1950 to 20.4 billion barrels in 1973. (See Table 2.) This rise in production far outdistanced population growth, leading to an increase in oil production per person from 1.52 barrels in 1950 to 5.34 barrels in 1973.

Table 2: World Oil Production, Total and Per Capita, 1950-78

Year	Population	Oil Production	Oil Production Per Person
	(billion)	(billion barrels)	(barrels)
1950	2.50	3.8	1.52
1951	2.54	4.3	1.69
1952	2.59	4.5	1.74
1953	2.63	4.8	1.83
1954	2.68	5.0	1.87
1955	2.72	5.6	2.06
1956	2.77	6.1	2.20
1957	2.82	6.4	2.27
1958	2.88	6.6	2.29
1959	2.93	7.1	2.42
1960	2.99	7.7	2.58
1961	3.04	8.2	2.70
1962	3.10	8.9	2.87
1963	3.16	9.5	3.01
1964	3.22	10.3	3.20
1965	3.29	11.1	3.37
1966	3.35	12.0	3.58
1967	3.41	12.9	3.78
1968	3.48	14.1	4.05
1969	3.54	15.2	4.29
1970	3.61	16.7	4.63
1971	3.68	17.7	4.81
1972	3.75	18.6	4.96
1973	3.82	20.4	5.34
1974	3.89	20.5	5.27
1975	3.97	19.5	4.91
1976	4.04	21.2	5.25
1977	4.12	21.8	5.29
1978	4.21	22.0	5.23

Source: United Nations and U.S. Department of Energy.

"To the extent that world population projections have implicitly assumed that the rise in per capita petroleum production would continue, they must now be reconsidered."

This dramatic growth contrasts sharply with the period from 1973 to 1978, which was inaugurated by the quadrupling of oil prices by the Organization of Petroleum Exporting Countries (OPEC) in late 1973. The OPEC announcement introduced a new era in oil production and pricing trends and reduced the annual growth in world oil production from 7 percent to less than 2 percent, roughly the same as population growth. As a result, oil production per person did not increase at all during the 1973-78 period.

The Iranian revolution in 1979 is directly affecting oil production and export trends in that country—until recently the world's second ranking exporter. But even more importantly, the Iranian revolution is triggering a reassessment of oil pricing and production policies in exporting countries that may have an effect on world oil production trends second only to that of the late 1973 OPEC price rise. To the extent that world population projections have implicitly assumed that the rise in per capita petroleum production would continue, they must now be reconsidered.

Among other things, the Iranian experience illustrates some of the difficulties of designing projects that can distribute the benefits of vast capital investments within a society in an equitable manner. In Iran, the windfall of wealth, as export earnings climbed from $4.8 billion in 1972 to some $22 billion in 1974, became concentrated in a few hands, widening the gap between rich and poor and putting an intolerable strain on the country's social fabric. When asked about the overthrow of the Shah's government, a deputy minister of oil from an Arab country who had represented his country at the December 1978 OPEC conference said, "The one thought that keeps coming back is that it could have happened to any of us."[14]

Official thinking in Mexico already reflects this concern with the social impact of an abrupt influx of capital. Although the United States and other oil importers had initially assumed that the newly discovered oil fields in Mexico would quickly bring that country into the ranks of the major petroleum exporters, the Mexican Government may be thinking otherwise. A recent report from Mexico City indi-

cates the government is already struggling to prepare projects capable of receiving an estimated influx of $5 billion in 1980. Officials of PEMEX, the state oil monopoly, have recently talked of a production plateau by late 1980 of 2.25 million barrels a day, of which about 40 percent would be for export. A growing number of Mexican officials, including President López Portillo, feel that "output should be kept down to levels commensurate with the country's ability to absorb the resulting massive revenues."[15]

The growing economic strength and independence of the oil-exporting countries is also influencing oil production and export levels. This new independence is dramatically evident in Iran itself, where the new leaders appear to be opting for a production level of 3 to 3.5 million barrels a day, which is just half the pre-revolutionary level of some six million barrels per day. After 700,000 barrels are set aside for domestic needs, the exportable oil supply would be scarcely half of the earlier level. This recent policy was outlined by the new director of the Iranian Oil Company, Hassan Nazik, who explained to reporters that "our production policy will be dictated only by Iran's national interest."[16]

The sharp increase in oil prices in 1979 is certain to influence world petroleum consumption. In the normal operation of any commodity market, rising prices simultaneously discourage consumption and encourage production. In the case of oil, a rising price not only discourages consumption, but in some key oil-exporting countries it discourages production as well. In countries with limited capital needs, a higher price satisfies these needs with a lower volume of exports. Indeed, some OPEC members, such as Libya and Kuwait, responded to the fourfold 1973 price increase by sharply reducing their oil exports immediately thereafter.[17] A similar response by some OPEC members can be expected following the price rise of 1979.

Inflation is also likely to discourage oil production in the short term. Uncertainty about the future value of money, particularly of the dollar, provides a logical reason for oil-producing countries to keep as much of their wealth as possible in the form of oil underground.

"In some countries a 'depletion psychology' will act to slow production as the extraction of oil begins to substantially exceed new discoveries."

With the almost certain knowledge that oil prices will climb above $20 a barrel in the not-too-distant future, the advantages of conservative oil production policies will become clearer to oil-producing countries. 21

In addition to these factors, it is quite likely that in some countries a "depletion psychology" will act to slow production as the extraction of oil begins to substantially exceed new discoveries. Countries will be forced to reckon with the day when their oil reserves are exhausted. The problem this poses for the exporters is far greater than merely that of substituting new energy sources for petroleum. They will also have to adjust to the loss of a major source of revenue. At some point, the urge to postpone the day when the wells go dry could become compelling. This fear of using up the last of an irreplaceable resource is a subtle factor, not easily measured, but just as the changing market psychology led to a dramatic oil price increase in late 1973, so the emergence of a depletion psychology could markedly reduce oil production.

Future world petroleum production trends will represent the net effect of production that is declining in some countries and rising in others. Production in several major producing countries has already peaked and begun to turn downward, in some cases because of dwindling reserves and production capacity and in others because of a desire to stretch out remaining reserves. Oil production in Venezuela reached 3.7 million barrels per day in 1970 and has declined nearly 40 percent since then. Production in Libya peaked in the same year at 3.3 million barrels a day, and fell to roughly 2 million barrels a day by 1979.[18]

In North America, U.S. production peaked in 1970, while Canada's high point was reached in 1973. Production in both has dropped substantially since then. Other important producing countries experiencing declines in recent years include Algeria, Iraq, and Kuwait. With the recent decision to lower oil output in Iran, that country may now be past its peak production years.[19]

22 Countries where production in the future is likely to increase most rapidly are China, Mexico, the Soviet Union, and the United Kingdom. Future gains in both China and the Soviet Union will depend in part on access to advanced oil-drilling equipment from the West. For China, imported equipment is essential if offshore fields are to be exploited in the near future. Production in the UK's North Sea fields, which totaled just over 1.1 billion barrels in 1978, is projected to climb rapidly in the immediate future, peaking at about 3 billion barrels in 1983. How much overall production increases in the immediate future hinges heavily on whether Saudi Arabia chooses to step up its output to compensate for the marked reduction in Iran. The Saudis could increase production from the 8.5 million barrels per day in 1978 to perhaps 11 million barrels per day, but they appear reluctant to do so.[20]

In retrospect, it is clear that the fourfold OPEC price rise in late 1973 ushered in a new era in world oil. It dramatically altered not only price policies but long-term production and consumption trends as well. Although it is too early to judge all the implications of the 1979 Iranian revolution and the associated reassessment of oil pricing and production policies, it seems clear that higher world prices and lower production trends are in store. Its impact may be greatest in those oil-exporting countries that have small populations. It will undoubtedly encourage other exporters to define their oil production and export policies in terms of their national interest. When this is combined with the other factors likely to restrict future production levels, it suggests an even slower growth in world oil output than has prevailed since 1973.

Several independent projections of world oil production made by petroleum companies and private consultants before the 1979 Iranian revolution indicated an annual rate of growth to 1990 of somewhere between 1.4 and 2.9 percent.[21] However, considering the direct and indirect impacts on production of the Iranian revolution and the other forces discussed above, increases in overall production between now and 1990 may not average more than 1 percent per year. This would be down somewhat from the 1.6 percent per year of the 1973-

78 period. Just as the 1973 OPEC price rise slowed the growth in world oil production from 7 percent to 1.6 percent per year, the 1979 price rises along with those in prospect are likely to slow further the growth in production.

If projected population growth materializes, a 1 percent growth rate in oil production would lead to a steady per capita decline. Between 1978 and 1990, overall production would increase by some 12 percent but production per person would fall from 5.23 barrels to 4.66 barrels. (See Table 3.) As oil reserves dwindle and as more countries try to stretch out their remaining reserves, total oil production is likely to turn downward around 1990, declining slowly from that point onward. As overall output declines, production per person falls rapidly, dropping from 4.66 barrels in 1990 to 3.55 barrels in 2000. Whether world oil production follows the exact path projected here is not of overriding importance. What is important is not only that the period of rapid growth in per capita oil output has ended but that the oil produced per person at the end of the century will be far less than it is today.

Table 3: World Oil Production, Total and Per Capita, Projected to 2000

Year	Population	Oil Production	Oil Production Per Person
	(billion)	(billion barrels)	(barrels)
1978	4.21	22.0	5.23
1980	4.37	22.3	5,10
1985	4.82	23.4	4.85
1990	5.28	24.6	4.66
1995	5.76	23.4	4.06
2000	6.25	22.2	3.55

Source: Population projections, United Nations; oil projections, Worldwatch Institute.

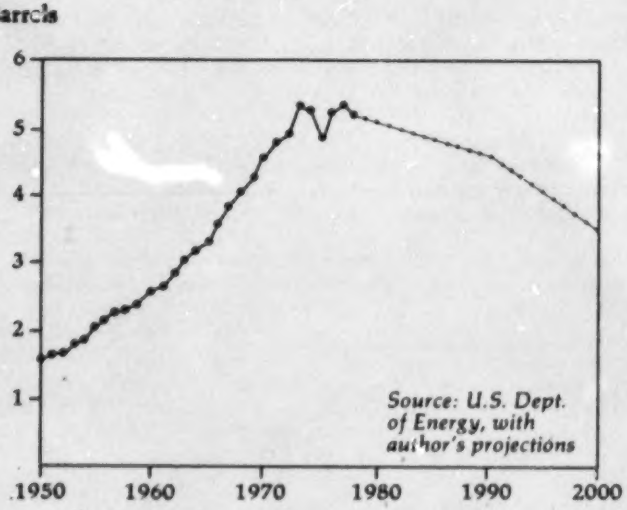

Figure 2. World Oil Production Per Capita 1950-78, With Projections to 2000

This analysis suggests that the last half of the twentieth century may divide into three distinct periods in terms of per capita oil production: from 1950 to 1973, when oil production per person climbed rapidly, reaching a new high every year; from 1973 to 1978, when it was static; and from 1978 to 2000, when it will be declining, perhaps by as much as one-third. (See Figure 2.)

The transition from an era of rapidly rising oil production per person to one of static oil output per person coincides with a pronounced change in the performance of the world economy. The 1950-73

"Continuously expanding human demands are overriding the capacity of new technology to offset the constraints inherent in natural systems."

period was one of unprecedented economic growth throughout the world. Since then there have been severe stresses on the international economic system. It is impossible to determine the extent to which the convulsions in the world economy since 1973 are due to the changing oil supply situation, but few would doubt that there is a relationship. If the transition in oil production per person from rapid growth to stagnation contributed to the economic stresses of recent years, what will a further transition to declining oil production per person lead to?

A decline in the oil supply per person does not necessarily translate into a decline in *energy* supply per person, provided other energy sources are being brought into use as the oil wells begin to go dry. Unfortunately, most governments have been very slow to respond to the prospective downturn in oil production per person. Only Brazil, with its national alcohol fuel program, and South Africa, with its coal liquefaction program, have plans for operating their economies in the post-petroleum era.[22] Minimizing the impact of the decline in per capita supplies will require vigorous conservation programs to eliminate waste and the establishment of priorities in oil use to assure adequate supplies for essential purposes such as food production.

Economic and Social Stresses

As world population approached four billion, the global economy was staggering under the first double-digit inflation during peacetime. The decade in which population reached the four billion mark has brought the highest unemployment since the Great Depression and a marked slowdown in global economic growth. For the first time since the beginning of the Industrial Revolution, there are signs that continuously expanding human demands are overriding the capacity of new technology to offset the constraints inherent in the natural systems and resources on which humanity depends.

26 As world population moves toward five billion, there is widespread evidence of excessive demand. Overfishing is now the rule rather than the exception, forests are shrinking in most countries, overgrazing is commonplace on every continent, and at least one-fifth of the world's cropland is losing topsoil at a rate that is undermining its productivity. Demand pressures appear to be converging as output per person of key resources of biological origin declines and as production per person of oil threatens to turn downward. For much of the period since mid-century, the open-ended substitution of oil and oil products for cropland and for products of the major biological systems served as a safety valve. That safety valve may now be closing.

The projected decline in world oil production per person from now until the end of the century contrasts so sharply with the tripling of production per person that occurred between 1950 and 1973 that it is difficult to assess its impact on the global economic system. It was relatively easy to substitute oil-derived synthetic products for many commodities of biological origin when the oil supply per person was climbing rapidly, but as per capita output declines, this will be far more difficult. Likewise, the use of petroleum and petroleum products to offset the shrinkage in cropland per person will become more difficult. To the extent that the leveling off of oil production per person during the seventies contributed to the simultaneous leveling off of food production per person, the prospective downturn in oil production per capita is a matter for concern.

One of the earliest signals of excessive demand is inflation. Overall increases in demand are the product of population growth and rising incomes. To the extent that supply increases are not adequate to cover both, prices rise. When the supply of so many basic resources fails to keep pace with even the population component of increasing demand, it should come as no surprise that inflation rates are accelerating.

Global double-digit inflation in peacetime did not exist prior to the downturn in per capita production of several basic commodities.

"Inflation could become a powerful contraceptive force in the future."

From 1958 to 1967, the annual rate of inflation among the members of the Organization for Economic Cooperation and Development (OECD), which accounts for a major share of the global output of goods and services, was 2.5 percent. From 1968 to 1972, it increased to 4.8 percent. As world population approached four billion, the pace of inflation accelerated further. By 1974, it had moved into the double-digit range, topping 10 percent. In 1976, following two consecutive years of recession in the OECD countries, it was still running at 7 percent. In 1979, worldwide double-digit inflation again looms on the horizon.[23]

In both the food and energy sectors, efforts to rapidly expand output appear to be facing rather steeply rising cost curves. Even countries that are reasonably well endowed in these sectors are finding it difficult to hold the line on prices. In early March 1978, Soviet officials announced an overnight doubling of gasoline prices that they justified in terms of "the growing cost and difficulty of developing the remote oil fields of Siberia."[24] At the end of 1978, following the largest harvest in history, the U.S. Department of Agriculture projected an increase in U.S. food prices of 6 to 10 percent for 1979.[25] If the Soviet Union and the United States, countries richly endowed in the energy and food sectors respectively, face higher costs and prices, then the difficulties facing less well-endowed countries are worrisome indeed.

At the individual level, accelerating inflation provides one of the strongest signals that all is not well in the relationship between a continuously expanding world population and the earth's natural systems and resources. Indeed, inflation could become a powerful contraceptive force in the future. One way to cope with rising prices is to limit family size and the need for purchased goods. A recent visitor to southern Senegal was surprised to find that villagers who a few years ago were not interested in contraceptives now took a lively interest in them. The apparent reason was that they, like Third World villagers elsewhere, were caught in a vicious inflationary squeeze. Prices of many of the consumer goods they had to buy, such

28 as firewood, kerosene, grain, and clothing, had virtually doubled over the past three years.[26]

In more advanced industrial societies such as the United States, where the cost of raising and educating a child is now estimated at close to $70,000, the impact of inflation may be even greater than in Third World villages.[27] In addition to its direct impact on childbearing decisions, inflation may push more women onto the job market as couples attempt to protect their standard of living. As the share of women in the paid work force rises, birth rates usually decline.

One of the clearest signs of resource constraints on the economic system is the slowdown in economic growth during the seventies. From 1950 through 1973, the global economy expanded at some 4 percent per year. During the 1974-79 period, growth has averaged only some 3 percent yearly.[28] This recent slowdown may not necessarily constitute a new trend, but the preceding analysis makes it easier to understand why the global engine of economic growth is losing steam.

In some situations, a slower rate of economic growth can lead to a decline in the quality of life. The 4 percent annual world economic growth rate during the 1950-73 period provided for a margin of some 2 percent over population growth. Roughly half the growth in output of goods and services during this time went to raising individual consumption levels. But when economic growth fell to 2 to 3 percent per year, in some countries the margin over the rate of population growth became perilously thin.

A fall in the economic growth rate to 2 percent per year would not pose any serious problem for West Germany or Belgium, where population growth has ceased. Indeed, incomes there would still rise by some 2 percent per year. But in Senegal or Pakistan, where population is still expanding by 3 percent or more per year, a 2 percent rate of economic growth would lead to a steady decline in the standard of living.[29] In many societies, the hope of sustained improvement in living standards is slowly evaporating.

While inflation may affect population growth primarily through its impact on childbearing decisions at the individual level, the slowdown in economic growth may accelerate adoption of national policies and programs to bring population growth to a halt. As it becomes more difficult to expand the output of goods and services, the advantages of slowing population growth will become more obvious to governments, particularly in those countries where population growth is most rapid.

Closely associated with the slowdown in economic growth is a worldwide increase in unemployment. The problem posed by the vast numbers of young people who will be entering the job market between now and the end of the century is enormous. Even if the resource base was expanding rapidly, this need for jobs would thoroughly challenge the ingenuity of governments. Historically, employment was created by adding more land to the cultivated base. As long as there were frontiers of settlement to push back, this was relatively simple. By the mid-twentieth century, the frontiers of human settlement had largely vanished, but by then energy was becoming cheap as the world entered the petroleum age.

Cheap energy and a relative abundance of resources from mid-century until 1973 set the stage for an unprecedented era of economic growth—and of job creation. Then as energy costs soared during the seventies, so did unemployment. The advanced industrial countries experienced the highest level of joblessness since the thirties. Unfortunately, during the remainder of this century there will be neither frontiers to push back nor cheap energy. Other ways of creating employment will have to be found.

At some point inflation, unemployment, and declining per capita income begin to take a social toll. They lead to hunger and malnutrition, increased sickness and disease, higher infant mortality, and reductions in life expectancy. Throughout much of the period from World War II until the early seventies, basic social indicators improved throughout the Third World. Life expectancy made impressive gains in virtually all developing countries. Unfortunately, this period

30 of widespread social progress may have come to an end in many countries during the seventies as the per capita food output dropped and the prices of basic foodstuffs soared.

In a number of low-income countries, the food situation has deteriorated markedly after poor harvests. After a quarter-century's absence, famine reappeared in the early seventies. Several of the Sahelian zone countries in Africa were affected. Ethiopia lost 300,000 lives to famine in 1974. In Asia, famine reappeared in both India and Bangladesh. In three of the poorest states in India, death rates climbed dramatically during the food crisis of 1972. In Bangladesh, death rates climbed sharply in 1972 and again in 1974, claiming several hundred thousand lives.[30]

The rich can adjust to higher food prices by increasing their food expenditures, but the poor, who are already spending virtually all their income on food, often do not have that option. They must tighten their belts. Whenever higher food prices have led to lower food consumption among the poorer segments of global society, they have exacted a heavy social cost. Demographer Davidson Gwatkin of the Overseas Development Council points out that the postwar convergence in life expectancy between the Third World and the industrial countries has virtually come to a halt during the seventies.[31]

In some densely populated parts of the world, continuing population growth is leading to a decline in living levels. A report from Egypt indicates that "the mass of the population is poor and getting poorer. The percentage of the rural population living below the poverty line and unable to satisfy their basic needs increased from 3 million (27 percent) in 1965 to 5.8 million (44 percent) in 1975." Writing about Bangladesh, the World Bank said, "It is depressing to have to report that with the likely levels of aid, the most that a very efficient conduct of policy in Bangladesh will possibly be able to achieve is to substitute stagnation for decline."[32]

From Mexico, Alan Riding writes of the prospective doubling of that country's population and wonders whether its "precarious economic

and political structures" might not "buckle under the strain." He describes the massive migration of landless rural laborers from the countryside to Mexico City "where the increasing influx has spawned huge slums that lack running water and minimal sanitation and that are known poignantly as 'lost cities'."[33] Its oil wealth notwithstanding, Mexico may find that it is not easy to reverse a history of economic mismanagement, as the Shah of Iran discovered.

Industrial countries are not immune to some of the economic maladies associated with population growth. For example, the Japanese are finding that although their incomes approach those of some West European countries, they are not able to enjoy the same quality of life because of extreme crowding, lack of living space, and scarcity of natural recreation areas. An influential Tokyo newspaper columnist argues that under conditions of extreme crowding, affluence is a meaningless concept.[34]

As world population pressures mount, governments may find it necessary to ration scarce resources such as food and fuel. If human numbers are not controlled, regulation and regimentation could become a way of life. Resource shortages, inflation, and unemployment will put a great deal of stress on social institutions. As long as the economic pie is expanding rapidly, everyone at least has the hope of a higher standard of living. But once that rapid expansion ceases, the question of how the pie is divided becomes a sensitive political issue. Where the rate of economic growth has fallen below population growth, as has recently been the case in some Third World countries, the pressures to redivide the pie can become particularly intense.

Distributive struggles are also fueled by inflation and the personal insecurity that comes with it. As future price rises are anticipated, they may be incorporated into wage demands, profit margins, and preemptive price hikes. Few things worry political leaders more than inflation, as it erodes both living standards and confidence in social institutions.

32 The failure of governmental policies to control inflation or reduce unemployment is due not to a sudden loss of skills by economic advisors, but rather to the spiraling human demands on the earth's natural systems and resources. Traditionally, fiscal and monetary policies could be used to control inflation but these old remedies are no longer adequate, in part because inflation is now being fueled by mounting population pressures. Fiscal policy can be used to eliminate excessive public expenditures but it cannot restore a forest or halt the deterioration of cropland due to excessive food demand. Monetary policy can be used to slow the rate of economic growth but it cannot save an oceanic fishery if the level of demand exceeds the fishery's sustainable yield. Monetary and fiscal policies are useful for making marginal adjustments in the economy, but they cannot deal with the fundamental population/resource imbalances unfolding as world population moves from four to five billion.

There may not be any precedent for the economic situation now unfolding. Political leaders may find it necessary to go beyond the economic advisors usually seated at their elbows and turn to the directors of family planning for help. Governments that do not have a policy to stabilize population size may find it necessary to formulate one. Indeed, the pressure on resources may have reached a point where long-term national efforts to cope with inflation will not succeed without a concerted global effort to slam on the demographic brakes.

As population growth continues, it is likely to contribute to more and more problems that governments will be unable to solve. Canadian Prime Minister Trudeau's belief that "we all face problems that we cannot easily solve" sums up the prevailing mood in many national capitals.[35] One possible consequence of such a situation may be more frequent changes of government, making the effective address of the long-term causal factors even more difficult.

Unless the deterioration of the natural systems on which the earth depends can somehow be arrested, and unless the wasteful use of oil can be quickly reduced, the seemingly unmanageable economic

"Monetary and fiscal policies cannot deal with the fundamental population/resource imbalances unfolding as world population moves from four to five billion."

stresses of the seventies could become merely the prelude to the cumulative economic stresses and social unrest of the eighties and nineties. The problems that arose as world population increased from three to four billion may seem trivial compared with those in store as human numbers go from four to five billion and beyond.

Population Policies: The Response So Far

Although the pressures of population growth on the earth's resources have been mounting for some time, governments have been slow to respond to the threat. Prior to 1965, only a handful of Third World countries officially supported family planning. But beginning in 1965, when seven of them launched programs, the international spread of family planning began to gain momentum. The decade from 1965 through 1975 was one of spreading official acceptance of family planning. At the end of 1975, only three of the 38 developing countries with ten million or more people—Burma, North Korea, and Peru—were not providing at least limited support for family planning. By 1979, all but a few Third World countries had policies, at least on paper, intended to achieve slower growth.[36]

The extent and effectiveness of these national programs varies widely. Some governments merely permit private programs to operate, while others make solid commitments of public resources and leadership attention. For example, Indonesian President Suharto, a staunch supporter of his country's program, meets quarterly with the provincial governors to review local progress and to focus on any roadblocks to the adoption of family planning that might have developed.[37] In some countries, the adoption of official population policies and family planning programs has had little impact on birth rates. In others, birth rates have been cut in half. The reasons for adopting population policies and family planning programs are as diverse as the outcomes.

In Mexico, it was the projected rise in national unemployment that gave cause for concern. Economic planners pointed out to the politi-

cians that even if Mexico maintained the rather robust economic growth rate of 7 percent that prevailed during the late sixties and early seventies, only a fraction of all the young people who would be seeking jobs in the years ahead could be productively employed. This analysis had a sobering effect on the Mexican political leadership; in his September 1973 State of the Nation Report, President Echeverria announced that Mexico was abandoning its pronatalist policy in favor of one that would encourage smaller families.[38]

Egyptian interest in family planning was triggered by a simple back-of-the-envelope calculation: the great Aswan Dam would irrigate enough farmland to feed an additional four million Egyptians, yet the country's population increased by ten million during the years it was under construction. This eventually led to a family planning program that was intended to reduce the crude birth rate by one point per year from 1969 to 1979.[39]

Within China, the national leadership began to recognize by the late sixties that the hard-earned economic and social gains since 1949 were likely to be undermined if population growth was not checked soon. With close to one-fourth of the world's population and scarcely one-eighth of the world's cropland, the Chinese were among the first to confront the Malthusian nightmare that unlimited population growth could bring. They responded with one of the most vigorous family planning programs in the world.

In Brazil, initial support for the family planning program apparently came from members of the medical community who supported "the need to make contraception acceptable to the population as a whole as a basic instrument of social well-being." The impact of rapid population growth on the distribution of income was also a matter of concern. Roberto de Oliviera Campos, former Minister of Planning in Brazil, points out that while the educated and wealthy have access to family planning information and anti-conceptive devices, "the poorer masses are loaded with unwanted children." He further notes that there has been a "dramatic realization that unbridled reproduc-

tion is a very effective way of perverting the pattern of income distribution." The official shift from a pronatalist, anti-family planning policy to one supportive of birth control came in 1974. Dr. Walter Rodrigues, executive director of the Sociedade Civil de Bem-Estar Familiar do Brasil (Family Planning Association), reports that the turning point came when the Brazilian delegation to the World Population Conference in Bucharest indicated that "recourse to birth control should not be the privilege of rich families, and therefore it is the responsibility of the State to provide both the information and the means to meet the needs of poorer families."[40]

One of the most recent indications of a possible shift in national population policy has occurred in Algeria, a country that has traditionally been at best indifferent to family planning. In an address to the National Union of Algerian Peasants in the spring of 1978, the late President Boumedienne said: "As you know, the productive acreage in Algeria is limited and the amount of rainfall is irregular. . . . At the time of our independence [1962] we numbered ten million; today, according to the latest statistics, the population of Algeria surpasses 18 million. How many of us will there be a decade from now?" He went on to note the widespread degradation of soils and to observe that "the land has become an immense construction site." Pointing to the extensive rural-urban migration that has led to an unmanageable growth of cities, he stated flatly that "Algiers can contain no more people." He noted similar circumstances in other leading cities such as Oran and Constantine, and hinted that official controls on rural-urban migration might be necessary.[41]

Although the demographic transition theory holds that birth rates fall only as living standards rise, there is now some evidence that extreme poverty can itself generate a demand for family planning services. In both Bangladesh and parts of Java, some of those living in abject poverty are turning to family planning as a possible means of improving their conditions.[42] If the poorest of the poor are indeed taking advantage of family planning services, it enhances the prospect of a rapid fertility decline in Third World countries.

Beyond the acceptance or, in some cases, promotion of family planning programs, some governments have set specific targets for reducing their birth rates. Prominent among these are several of the more populous countries in Asia. Indonesia hopes to reduce its population growth rate from 1.6 percent in 1977 to 1.3 percent by 1981. Thailand, a relative newcomer to the family planning field, proposes to drop its population growth rate to 2 percent by that date. India, in early 1978, adopted a birth-rate target of 30 by 1983, although previously it was hoped this rate would be reached by 1979. The less ambitious target reflects recent setbacks in family planning.[43]

In February 1978, Premier Hua Kuo-feng announced that China's annual population growth rate would have to be cut to 1 percent by 1981. At the Fifth National Peoples' Congress, Hua said that "planned control of population growth is conducive to the planned development of the national economy and to the health of mother and child. . . . We must continue to give it serious attention and strive to lower the annual rate of growth of China's population to less than 1 percent within three years." This goal may be less ambitious than it seems, as China's annual population growth is already close to 1 percent.[44]

Egypt, with one of Africa's largest populations, has fallen short of its target of reducing the birth rate by one point per year over the past decade. Although the birth rate has fallen somewhat, the official target has not been reached largely because of the ineffective leadership of the family planning program and numerous administrative and logistical problems. In Mexico, the López Portillo regime has adopted a goal of progressively lowering the population growth rate during each six-year plan until it is reduced to 1 percent per year by the end of the century.[45]

The increase in official support for family planning and for population growth targets has been paralleled by the financial contributions to these programs. The budgets of the principal international family planning agencies—the International Planned Parenthood Federation, the U.N. Fund for Population Activities, and the population office of

the U.S. Agency for International Development—have all increased markedly since the beginning of the decade.

The growth of financial support for international population and family planning programs during the seventies has been encouraging, though far from adequate. Between 1970 and 1977, government contributions rose from $90 million to $258 million; of these totals, the U.S. portion went from $74 million to $140 million. Denmark, Japan, the Netherlands, Norway, Sweden, the United Kingdom, and West Germany all became major contributors.[46] All indications are that this support will continue to grow as more developing countries request assistance for their programs.

While several industrial countries now have stable populations, and while a number of Third World governments have well-designed programs aimed at achieving population stability, most governments are falling short of the effort needed. Many industrial countries do not have a formal population policy, much less one designed to stabilize population size. In scores of developing countries, a majority of couples at risk still do not have ready access to contraceptive services.

A Population Stabilization Timetable

The basic frame of reference for formulating population policy is changing. Over the past few decades the desire to more quickly achieve basic social goals, such as higher incomes or better diets, led to policies to slow population growth. These policies served their purpose well, but now the deterioration of biological systems and the depletion of oil reserves call for policies to stabilize population size. Without a concerted effort to stabilize population size at a level far lower than currently projected, a deterioration of the earth's biological resource base and of the living standards of more and more of the world's people may be inevitable.

38 There may still be some who believe that world population will grow to 12 billion before coming to a halt. If so, the onus is on them to demonstrate how the productivity of the earth's fisheries, forests, grasslands, and croplands can be maintained in the face of such pressures. They must also be prepared to identify the energy sources that could support such a population.

Given what is now known about the carrying capacity of the earth's natural systems and the reserves of nonrenewable resources, particularly oil, at what level should world population be stabilized? Avoiding a decline in the per capita fish catch would have been possible if world population growth had come to a halt at 3.6 billion in 1970. If population had stopped growing at 3.8 billion, grain output per person might still be increasing. And if it had topped off at four billion, there would be much more time to develop alternatives to oil.

Unfortunately, the advantages of stabilizing population growth are matched by the difficulties of doing so. Demographers are quick to point out that even if fertility rates were to fall immediately to replacement level, population would continue to grow for several decades in those countries with a disproportionately large number of young people. They are quite right. In some societies, fertility may have to drop well below replacement level, with one-child families becoming the social norm. Indeed, Chinese leaders are already urging couples in urban communities to hold the line at one child.[47]

Any abrupt reduction in the birth rate will lead to wide variations in the size of various age-groups. These imbalances would in some ways be the reverse of the abrupt postwar rise in birth rates experienced by many countries during the late forties and the fifties and the associated pressures on child-care and educational institutions. A sharp rise in the birth rate leads to an immediate rise in the dependency ratio (the proportion of nonworkers to workers in a society), whereas with a sharp decline in the birth rate, the dependency ratio declines in the short run. Eventually it would rise again when there is a disproportionately large number of elderly people in the population, but there would be several decades to prepare for the increase.

"In some societies, fertility may have to drop well below replacement level, with one-child families becoming the social norm."

The great difficulty in bringing population growth to a halt quickly must be weighed against the social costs of failing to do so in time to avoid collapse of the earth's major ecological systems. On balance, the sum of the social stresses on both sides might be minimized if world population growth could be brought to a halt somewhere around six billion. The preceding analysis suggests that even six billion people would be excessive for some key resources, but it would be exceedingly difficult to stabilize at a lower level given the great momentum of population growth inherent in the large number of young people coming into their reproductive years. Adequately supporting even six billion people will not be possible without greatly improved management of biological systems, widespread rationing, stringent energy conservation measures, recycling programs, and a more equitable distribution of vital resources such as food, land, and petroleum.

Although exceedingly ambitious, stabilization of world population at six billion will not require any country to do what several countries have not already done. No country would have to reduce its birth rate any more rapidly than Barbados, China, Costa Rica, Indonesia, and Singapore already have. Other countries would, of course, have the advantage of being able to draw upon these earlier successes.

A stable world population requires a balance between births and deaths. National death rates range from a low of six (when there is a relatively young population in good health, such as in Malaysia or Sri Lanka) to a high in the twenties (such as in Ethiopia or Afghanistan). There is much greater variation in birth rates—from just under 10 in West Germany and 12 in the United Kingdom to 48 in Algeria and 47 in Nicaragua. Prior to the modern age, population stability was the product of an equilibrium between relatively high birth and death rates. With the introduction of modern medicine and sanitation, however, death rates dropped considerably; long-term stability in a modern society is likely to occur with birth and death rates in balance at about 13, as was the case, for example, in East Germany in 1977.[48]

40 Because of the wide differences in fertility levels in the world today, it is necessary to separate the industrial from the developing countries when devising a timetable for population stabilization. In the industrial countries, where populations are already growing slowly, it should be possible to achieve stability much sooner than in the less developed countries. Nearly a score of developed countries are already near or below replacement-level fertility.

Several industrial countries have already stabilized their population size, including Austria, Belgium, East Germany, Luxembourg, West Germany, and, most recently, Sweden and the United Kingdom. (See Table 4.) Together, these seven countries have an excess of deaths over births, leading to a modest decline in the size of their combined population. Of the roughly 22 percent of the world's population that lives in the industrial world, nearly one-sixth live in countries that have already achieved population stability.

Table 4: Countries With Essentially Stable Populations, 1977*

Country	Population	Birth Rate	Death Rate	Annual Rate of Change	Annual Change
	(million)	(per thousand)		(percent)	(number)
Austria	7.52	11.3	12.2	−.09	− 6,768
Belgium	9.83	12.4	11.4	+.10	+ 9,830
East Germany	16.77	13.3	13.4	−.10	− 1,677
Luxembourg	0.36	11.4	11.5	+.01	+ 36
Sweden	8.26	11.6	10.7	+.09	+ 7,434
United Kingdom	55.85	11.8	11.7	+.01	+ 5,585
West Germany	61.40	9.5	11.5	−.20	−122,800
Total	159.99				−108,360

*Excludes both emigration and immigration.
Source: United Nations.

The remaining industrial countries, which have relatively modest population growth rates, could bring their growth to a halt as early as 1985 if they wished. This would mean that France, Italy, Japan, the Soviet Union, the United States, and other smaller industrial countries need only replicate what has already happened in Belgium, the United Kingdom, or West Germany. It is not unreasonable to suggest that all industrial countries should strive for a stable population size by no later than 1985.

Interestingly, in the seven countries where population growth has already stabilized, there has been no conscious national effort to move in this direction. The decline in fertility was a result of major social changes, such as improved access to family planning services, the liberalization of abortion laws, high levels of education and literacy, and expanded employment opportunities for women. In some countries, population size would stabilize in short order if pronatalist economic policies such as "baby bonuses" were abandoned. In France, elimination of baby bonuses alone might be sufficient to eliminate the slight remaining surplus of births over deaths. The stabilization of population in the industrial societies is particularly urgent because of their disproportionately high consumption per person of global resources, especially oil.

For the developing world, population stabilization should be thought of in two stages. The first would involve reducing the birth rate from current high levels to 25 by 1985. From then until 2005, birth rates in most developing countries would remain at about the level of Soviet, U.S., and West German birth rates during the early sixties (20 to 25 per thousand). Between 2005 and 2015, when markedly smaller age-groups would be entering their reproductive years, it should be possible to take the final step of bringing the birth rate into balance with the death rate. At that stage, the developing countries would essentially be repeating the population stabilization path suggested for the industrial countries between now and 1985—bringing moderate growth down to zero.

42 Most developing countries will have to launch extraordinarily ambitious programs if they are to bring their birth rates down to 25 by 1985. It will require much more rapid changes in fertility than most observers have considered possible. Not all countries will reach this target, but some are ahead of schedule. China, for example, which contains nearly one-third of the total population in the developing world, already has a birth rate well below 25 per thousand. By 1981, the Chinese plan to have the population growth rate down to 1 percent, implying a birth rate of 18. It could be even lower by 1985. The birth rates in Cuba and South Korea are also now below 25, while those in Barbados, Hong Kong, and Singapore are below 20. Birth rates in Sri Lanka and Taiwan are already down to 26.[49]

At the other end of the spectrum, there are more than a score of countries in Africa with birth rates between 40 and 50. Many in this group also have death rates greater than 20. Needless to say, a country such as Ethiopia will have great difficulty getting its birth rate down from 49 in 1977 to 25 by 1985. If it does not check the growth rate soon, the famine that claimed 300,000 lives in 1974 could well return. The same applies to the string of countries across the southern fringe of the Sahara. The alternative to a steady reduction in birth rates may be sporadic rises in death rates.

Some knowledgeable observers may well declare the target proposed for the less developed nations to be "unattainable." However, consideration of the population size that many nations will be burdened with even if they do meet this stringent goal makes the prospect of *not* meeting it almost impossible to imagine. Under this timetable, India, already struggling to feed and maintain political and economic order among 635 million people, would have to cope with nearly one billion in 2015. Bangladesh, badly overcrowded and existing on a threadbare margin of survival with an estimated population of 85 million, would have to find the means of supporting an additional 50 million people.

Mexico, now dependent on the steady emigration of its workers to the United States to help alleviate its unemployment crisis, would

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grow from 67 to 103 million people. Nigeria would face a similar increase, going from 67 million to nearly 100 million. And Egypt, with a current population of about 39 million, would have to squeeze an additional 26 million people into the crowded Nile Valley even if it meets the proposed timetable.

Table 5: A Proposed Population Stabilization Timetable

	World Population	Annual Growth Rate	Annual Increase
	(billion)	(percent)	(million)
1970	3.6	1.9	69
1975	3.9	1.8	70
1985	4.5	1.1	50
2000	5.3	1.0	52
2005	5.5	0.9	49
2015	5.8	0	0

Source: Worldwatch Institute.

Under this timetable, the substantial declines in birth rates between now and 1985 in both the industrial and developing countries would reduce the annual world population growth to 1.1 percent in that year. (See Table 5.) This period would be one of steadily declining fertility throughout the world. Despite continuing stringent efforts to reduce births, there would be little further decline in the overall growth rate from 1985 to the end of the century. Populations in the more developed countries would already have stabilized, while in the developing world, the large number of people born during the 1960-75 period would be in their prime reproductive years. The second phase of the push toward stabilization would come during the decade from 2005 to 2015, when the people in the markedly smaller age-group born after 1985 would be entering their childbearing years. This would yield a stabilized world population of just under six billion by 2015. Even with these extraordinary efforts, the current world population would have increased by nearly one-half.

44 A Population Stabilization Program

There are numerous pressures that will spur governments and individual couples to act in a manner that will eventually stabilize world population size. Among them are the resource scarcities and economic stresses cited earlier—energy shortages, land hunger, the deterioration of basic life-support systems, inflation, crowding, and rising unemployment.

There is now considerable evidence that governmental policies can directly influence fertility, but most governments will not know how quickly they can check population growth until they have made a serious effort to do so. To date, only two countries—China and Singapore—have launched comprehensive programs to reduce birth rates. There are at least five areas in which governments can act to slow population growth: providing family planning services, improving social conditions (such as nutrition and literacy), reshaping economic and social policies (such as those governing the minimum age of marriage or the number of children for whom tax deductions can be claimed), improving the status of women, and encouraging population education to help people understand how population size affects the quality of life.

The provision of family planning services is one of the most obvious ways governments can help stabilize population growth. Although a good deal of progress has been made in expanding the availability of contraceptive services, a great deal still needs to be done. One recent study estimated that half of the world's couples still go to bed at night unprotected from unplanned pregnancies. There are very few societies in which all those in need have ready access to contraceptive services.[30]

In many societies where the demand for contraceptives preceded their availability, the initial provision of family planning services led to a sharp decline in birth rates. Such was the case in Costa Rica, where

the birth rate fell from 47 in 1961 to 28 in 1973. Demographer J. Mayone Stycos attributed much of the decline in fertility to the availability of contraceptives and to the high degree of literacy among both women and men. Ready access to contraceptive services is also a cornerstone of China's highly successful program. A Chinese official, Liu Ching-shen, told an American family planning delegation that "we practice the principle that anyone who wants birth planning can get it and the government should pay for it."[51]

Years of experience in many countries indicates that clinic-based contraceptive services are usually less effective than community-based efforts that involve local people in the setting of birth-rate goals, the design of the program, and the delivery of services. Indonesia's family planning program, described by Bruce Stokes as a unique blend of government initiative and local custom, has led to an impressive drop in fertility levels. On the island of Java alone, 27,000 village pill and condom depots, many of them in private homes, help provide ready access to contraceptive supplies. The dramatic drop in the Indonesian birth rate over the past six years indicates that a marked decline in fertility levels can result from making family planning services available with little or no accompanying improvement in social conditions.[52]

The achievement of a stable population will not be easy unless contraceptive services are backed by legal abortion. With the legalization of abortion in Italy, the share of world population living in societies where abortion is readily available reached two-thirds, up from one-third a decade ago. Yet this means one-third of the world's women are still denied this basic public health service, except on illicit terms.[53]

A second area where governments can facilitate the stabilization of population involves the improvement of social conditions. Paramount among these are nutrition, literacy, and infant mortality. Countries where social conditions have improved broadly are in an ideal position to achieve a rapid reduction in fertility levels. The widely

heralded success of family planning in Sri Lanka and the Indian state of Kerala attests to the mutual reinforcement of social improvement and family planning services.

A third and related area of governmental action is the reshaping of economic and social policies that directly or indirectly affect fertility levels. These include raising the minimum age of marriage, limiting the number of births with paid maternity leave, and limiting the number of children for whom tax deductions can be claimed.

Age of marriage, an important influence on birth rates, is rising in many countries, including China, Denmark, Sri Lanka, and the United States. In the last three it is rising because of economic and social forces, whereas in China it is more a result of a higher officially recommended age of marriage. Chinese leaders, fully aware of the role delayed marriage can play in reducing the birth rate, have officially recommended a minimum marriage age of 26 for men and 24 for women. Although difficult to enforce and apparently more widely accepted in urban than in rural areas, it appears to be a key contributor to the record declines in fertility in China. Princeton demographer Charles Westoff reports that in the United States, the share of unmarried women in the 20-to-24 age-group increased from 25 percent in 1960 to 43 percent in 1976. In Denmark, where population stability may be imminent, the figure increased from 44 percent in 1970 to 59 percent in 1975.[54]

In the island country of Sri Lanka, where the birth rate has declined steadily over the past two decades, the median age of marriage of women is 23.9 years, a reasonably high level by international standards. The World Fertility Survey reports that the share of women aged 20 to 24 who are not married "has steadily risen from about 30 percent in 1946 to about 60 percent in 1975," almost exactly the same level as Denmark's. Young Indonesians are also apparently delaying marriage. In both Sri Lanka and Indonesia, rising unemployment among young men appears to be a factor in delayed marriage. Parents are reluctant to have a daughter marry a young

man who does not have assured employment and who cannot afford to establish his own household.[55]

The conditions under which maternity leave is granted can directly influence childbearing decisions in societies where women are widely employed outside the home. Singapore gives a two-month paid maternity leave to women in civil service or unionized jobs only for the first two children. East Germany, on the other hand, in 1976 extended its full-pay maternity leave from 18 to 26 weeks as part of a package of new inducements designed to raise the birth rate and arrest the decline in its population size.[56]

Both the Philippines and Nepal have rewritten their tax laws to encourage small families. The Philippine law, rewritten in 1973, limits to four the children for whom tax deductions can be claimed. More recently, Nepal has gone even further, eliminating tax deductions for children altogether.[57]

A fourth area of social change that deserves attention in its own right is the improvement in the status of women. In Third World countries, fertility declines usually correlate more closely with rising education levels among women than with any other single indicator. Indeed, fertility often declines sharply as soon as women become literate.[58]

In virtually all the advanced industrial countries of North America and Europe, rising employment for women, in combination with other social and economic trends, is reducing fertility. In *The Sisterhood of Man*, Kathleen Newland reports that in the United States the share of women in the prime childbearing years who are employed has climbed from two-fifths in 1960 to three-fifths in 1978. Similar trends are unfolding in Europe. In the Soviet Union, the share of female employment outside the home is far higher. Soviet demographer Galina Kiselva writes that 93 percent of women aged 16 to 55 are either employed or in school. This great increase in female employment, she explains, "has brought about a transformation of the whole range of women's needs including the . . . need for children."[59]

48 An area where almost all governments are delinquent is population education. Merely understanding the arithmetic of population growth can itself influence attitudes and policies. An understanding of the relationship between population size and the carrying capacity of natural systems, particularly at the national and community levels, can markedly influence individual childbearing decisions. Education on these issues is particularly effective if people at the local level are involved in the analyses, the calculations, and the long-term planning for expected increases in the population. In China, the involvement of production-team members in calculating and planning the future balance between population and resources has been an important factor in the acceptance of that country's very bold birth planning program.

Many countries now encourage family planning, but China is the first to move to national birth planning. A national birth quota is apparently established each year in Peking as an integral part of overall economic planning. Two American demographers, the late Fred Jaffe and Deborah Oakley, report that commune officials "meet with their counterparts in each production brigade and transmit the target number of births for the brigade and its component teams during the coming year." At the production-team level these quotas are, in effect, translated into birth permits, with allocations made on the basis of age of the couple and their current number of children. A newly married couple in their late twenties would be high on the eligibility list. A couple in their mid-twenties with a newborn infant might be encouraged to wait a few years before having another child. According to Jaffe and Oakley, "The concern shown by the birth planning workers in these discussions, as well as the example set by officials of the brigade and team, were reported to be important in persuading couples to conform to the program goals."[60]

The lack of a population policy is a national luxury that the world can ill afford. If population policies are to be intelligent, and if demographic projections are to be meaningful, most countries need far more information on the sustainable yields of their grasslands, forests, croplands, and fisheries. The scarcity of data in most areas

"The lack of a population policy is a national luxury that the world can ill afford."

points to the need for assessments of the carrying capacity of local biological systems under varying demand pressures and levels of management.

National assessments of future energy supplies are also needed if population sustaining capacity is to be estimated with any confidence. The close relationship during the third quarter of this century between the growth in population and in oil supplies raises the obvious question of how scarce oil supplies will affect future population growth. Even more important is the question of how many people the earth can sustain at an acceptable standard of living in the post-petroleum era.

The poor understanding of the carrying capacity of the world's principal biological systems has led recently to economic summit conferences on the symptoms of excessive demand pressures—accelerating inflation, slowing economic growth, and rising unemployment—without any discussion of the underlying causes. Until this knowledge gap is filled it will be exceedingly difficult to formulate intelligent economic or population policies. One effort to fill this gap is the U.S. Government's Global 2000 Study, currently being prepared under the direction of the Council on Environmental Quality and the Department of State. Scheduled for release in late 1979, it represents a welcome initiative in this area.[61]

Bringing population growth to a halt is not in itself likely to solve many of humanity's pressing problems. In many cases, however, it is a necessary prerequisite. If the demographic brakes are not applied soon, overfishing, overgrazing, deforestation, overplowing, and their associated economic stresses are certain to worsen. The rapidly expanding demand for basic energy and food supplies is driving humanity up a rising cost curve. An immediate slowdown of world population growth will buy time to make needed adjustments and to develop new technologies and alternative energy sources.

As world population moves toward five billion, humanity is moving into uncharted territory in the relationship between population size

and the earth's natural systems and resources. If population continues to expand rapidly, it may well lead to a decline in the level of living for a large segment of humanity. It is difficult to judge how people will respond to economic and social stresses as they become more severe, for there is no recent historical precedent to indicate how a sustained erosion of living standards will affect reproductive behavior and family size.

The population problem is simultaneously a global problem and a local and individual one. In an interdependent world, plagued with resource scarcity, continuing population growth anywhere can affect people everywhere. All national political leaders will have to deal with the consequences in one form or another.

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